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Cooperative Research Project 1605 was concerned with the use of a computer (in the IBM 1620 SPS programing language) in designing school bus routes. This .s the concluding report of that project which is here converted into the FORTRAN language. Other objectives were to expand and refine the program, increase its speed, and reduce its costs. The revised program offers school administrators and transportation department heads an effective method of coping with the clerical tasks involved in school bus routing. The FORTRAN program yields the following outputs: bus routes with variable descriptions of pick-up points, times of arrival at, and return to a point, total student riding time, and total bus time, in terms of cost. The program has been thoroughly tested by several school systems. (Author/GO)

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DEVELOPMENT OF A FORTRAN COMPUTER PROGRAM TO DESIGN SCHOOL BUS ROUTES

February 28, 1969

U.S. DEPARTMENT OF
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Final Report

Project No. 8-D-049
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Development of a FORTRAN Computer Program to Design School Bus Routes

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February 28, 1969

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ERIC Report Resume	

PREFACE

This final report contains the FORTRAN version of the computer program to design school bus routes along with complete explanations of input data and sample input and output for the program. The rationale of the computer solution can be found in the final report of Cooperative Research Project No. 1605 and is not presented in this report.

I would like to thank George Hnilicka, Racine Public School System, Racine, Wisconsin, who kindly consented to test the FORTRAN version of the program on one of his small systems. He reviewed the User's Manual and made several constructive comments about the manual. Al Jensen, Computer Center, Racine Public School System, Racine, Wisconsin, and Mr. Hnilicka spent many hours reviewing the manual and testing the school bus FORTRAN program on their computer system. Their comments are included in this report.

Special recognition is given to Judson Nichols and his staff at the Dade County Public School System, Miami, Florida, for his continuous efforts in helping to test and evaluate the school bus scheduling program. Mr. Nichols has offered timely and constructive suggestions throughout a five-year period.

Special recognition is given to Robert A. Larsen, Robbinsdale Public School System, Robbinsdale, Minnesota, who has maintained a continuing interest in this program and has greatly encouraged continued work in this area.

If there are any errors in this report, the program, or the User's Manual, the director alone is responsible. Everything has been checked diligently in order to minimize mistakes, but inevitably some errors will still appear.

SUMMARY

Purpose

The purpose of this study was to convert to FORTRAN language the computer program that was developed in Cooperative Research Project 1605, "The Use of a Computer to Design School Bus Routes".

Scope

The original program was written in Symbolic Programming System (SPS), a language specifically for use with the IBM 1620 Computer. Because of demands for the program changes and developments in computer equipment, and because of the differences in the sophistication of personnel, greater application of the program is possible when written in FORTRAN, a more widely used computer language. Specific objectives were to: (1) convert the SPS program to FORTRAN language, (2) expand and refine the program to increase the speed, decrease the memory requirements, and (3) to present the program with detailed comments.

Contribution

The revised program offers school administrators and transportation department heads an efficient method of coping with the clerical tasks involved in school bus routing, thus enabling school systems to use more effectively both professional and clerical personnel.

Method

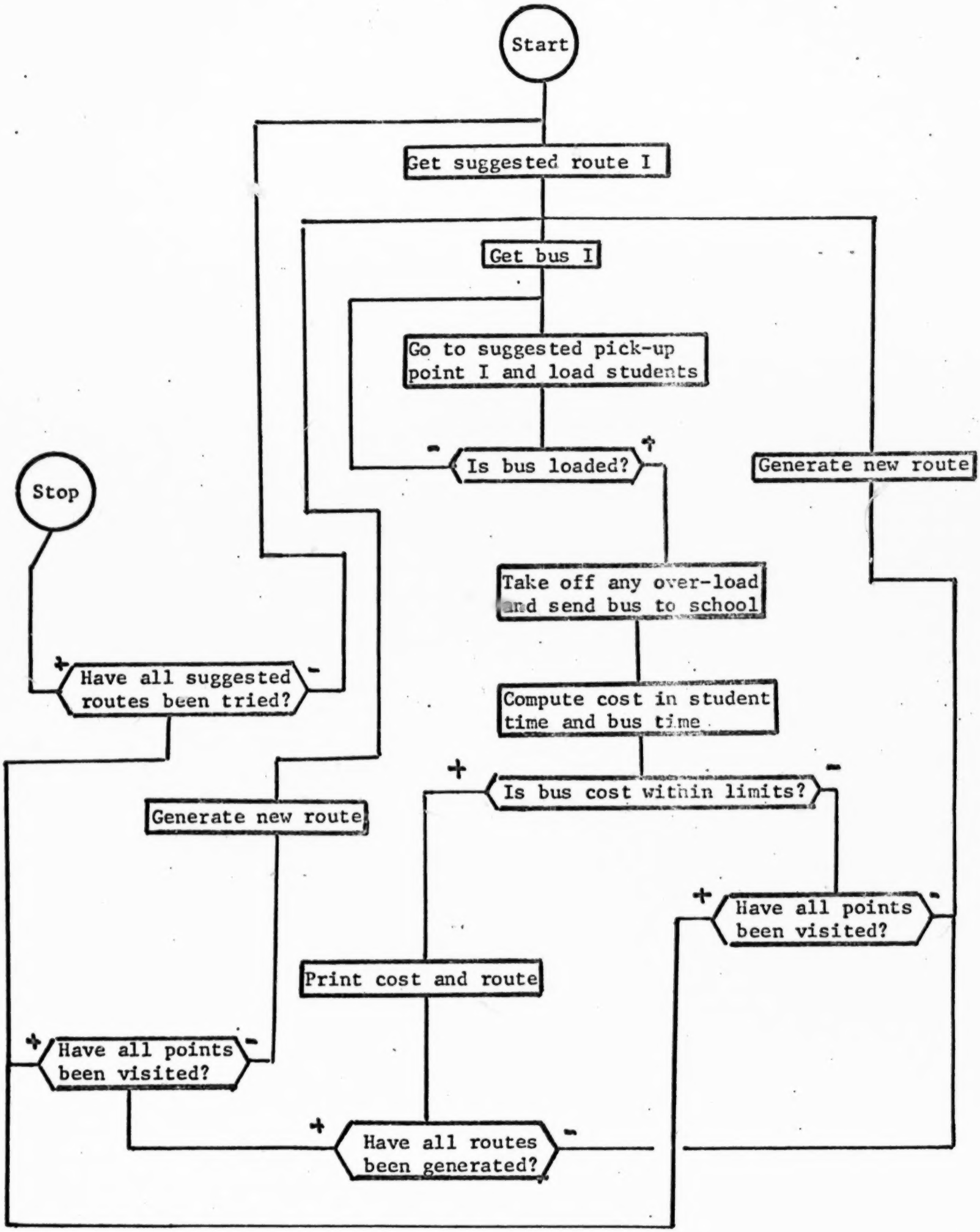
The present FORTRAN program yields the following outputs: bus route with verbal description of pick-up points, time arriving at point, and time returning to point; student riding time; and bus time (cost). The entire program has been tested by processing data from two independent school systems.

INTRODUCTION

The intent of this report is the presentation of a FORTRAN program that may be used in designing school bus routes. The explanation is directed toward transportation personnel in any school system who might wish to implement the program. The general procedure is a heuristic solution and no formal attempt has been made to analyze it from a mathematical (theoretical) point of view. A flow chart of the algorithm is given on the following page. Detailed descriptions of the development, definitions of all terms, and the evaluation of the algorithm has been presented in the final reports of Cooperative Research Projects 783 and 1605. These reports are available through Educational Resources Information Center (ERIC), ERIC Document Reproduction Service, National Cash Register Company, 4396 Fairmont Avenue, Bethesda, Maryland, 20014.

Since the outset of Cooperative Research Projects 783 (completed 1961) and 1605 (completed 1964), many requests for information and/or assistance have been received. The majority of these requests has come from city, state, and county public education personnel and from state college and university personnel. Specific requests have been received for the existing program converted to FORTRAN language.

Since the publication of Cooperative Research Project 1605, many improvements and refinements have been made to the existing program and these improvements have been described elsewhere (Boyer, Ross, and Ross, 1967).



Flow chart for school bus problem

METHODS AND RESULTS

The FORTRAN computer program is presented in Table 1. Every attempt was made to produce a readily comprehensible program; thus, many comments have been incorporated. The program is written in IBM FORTRAN IV, Level G and requires two sequential data sets (tapes or disks). The program has been tested on IBM 360/40 computer.

An operator's manual is given in Appendix A. As a result of the continuing improvements in data processing equipment and techniques and in school transportation methods, the manual is continuously being improved and any prospective user is advised to secure the most recent edition from the Project Director.

After reviewing the computer solutions for a relatively small rural attendance center, Mr. George Hnilicka, Racine Wisconsin, reported that the computer solutions tended to compare favorably with routes prepared manually, and in some cases, the computer solutions were better. Futhermore, he stated that the computer solutions probably would be much better in urban areas than in rural communities. In any attempt to use a computer program to design school bus routes, Mr. Hnilicka felt that some type of technical assistance would be highly desirable. He found the User's Manual (see Appendix A) to be very helpful because it contained a complete set of input and output data.

TABLE 1

```
C      MAIN LINE PROGRAM
       IMPLICIT INTEGER*2(A-Z)
       INTEGER * 4 CODE,RCODE,BUSX,KIDSX,LMATX
       INTEGER*4 BLANK
       INTEGER*4 NRC,MAXM,MILE,MMAXM
       INTEGER*4 ATYPE
       DIMENSION WORKK(3)
C  ***********************************************************************
C              NAME OF          CAPACITY OF      NO. OF  NO. OF TYPES
C              POINT            EACH BUS         POINT   OF KIDS AT POINT
       DIMENSION ATYPE(5),      NBC(50),      MPTN(150), MTYPE(150,5)
C
C              TOTAL NUMBER OF KIDS AT EACH POINT BY TYPE
       DIMENSION NTKID(5)
C
C                      POINTS IN SUGGESTED ROUTE
       DIMENSION       NSUG(150)
C
C                      ACCUMULATORS OR WORK AREAS
       DIMENSION      NACC(52),  MACC(52),LACC(52),NSUGW(150),KTYPE(5)
       DIMENSION SUBS(150)
C
C                      NUMBER OF        DISTANCE OF      MAXIMUM
C                      POINT            POINT            NUMBER IN EACH SET
       DIMENSION       LMAT(1500)      ,MLINK(1500)    , NML(150)
C
C                                                       RELOCATION
C                                                       FACTOR
       DIMENSION                                        NREL(150)
C
C                 STARTING POINT              MAX STUDENT RIDING TIME
C                      MATRIX                      FOR EACH BUS
       DIMENSION       NST(150),                   NBUSM(50)
C
C
C              OVERLOAD ALLOWED ON EACH BUS
       DIMENSION          NOVLD(50)
C
C  ***********************************************************************
       COMMON     NRC,MAXM,MILE,MMAXM
       COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
       COMMON LACC,NACC,MACC
       COMMON NTYPE,NML,NRTC,LINE
       COMMON RT,NBUSM
       COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
       DATA BLANK/' '/,BUSX/'BUS'/,KIDSX/'KIDS'/,LMATX/'LMAT'/
C  ***********************************************************************
C
1      FORMAT(20I5)
2      FORMAT(I5,18(A4,1X))
3      FORMAT(1H 21HCAN NOT GO FROM POINT I7,10H  TO POINT I7)
4      FORMAT(1H025HCANNOT PROCEED WITH ROUTE,I6/1H1)
```

TABLE 1 CONTINUED

```
5       FORMAT(1H1)
C
C   ***********************************************************************
        WRITE (6,5)
         REWIND 1
        REWIND 2
        NSST=800
        NEND=300
        DO 900 KKK=1,52
        LACC(KKK)=0
        MACC(KKK)=0
900     NACC(KKK)=0
9011    NTIMT=0
C   ***********************************************************************
C
C                   NO. OF                                          RETURN CODE FOR
C                   DIFF.                                           SUGG ROUTES
C                   TYPES                                           BLANK=NONE,BUS=NEW CAP
C                   POINT    NAMES OF DIFFERENT      PRINT        KIDS=NEW KIDS MATRIX
C                   INPUT    TYPES OF POINT INPUT    CODE         LMAT=NEW LMAT,MLINK MA
C                                                                 ALL=COMPLETE NEW SET
        READ(5,2,END=302) NTYPE, (ATYPE(J),J=1,NTYPE),CODE,      RCODE
C
C   ***********************************************************************
C
C       READ NUMBER OF BUS AND BUS CAPACITY AND MAX STUDENT RIDING TIME
C       FOR EACH BUS.  LEAVE NBUSM(K) BLANK IF MAX S R T IS TO BE COMPUTED
C       IF THERE IS AN OVERLOAD ALLOWED ON A BUS, ENTER IN THE FOURTH FIELD
C       READ UNTIL A (/*) IS  ECOUNTERED
C       ***************************************************************
C
        IF(CODE.NE.BLANK) WRITE(6,6611) NTYPE,(ATYPE(J),J=1,NTYPE),CODE,RC
       1ODE
6611    FORMAT(' '15,18(A4,1X))
9055    CONTINUE
        IF(CODE.NE.BLANK) WRITE(6,6666)
6666    FORMAT('0   BUS NO.  CAP MSRT OVLD')
        NBUS=0
95      CONTINUE
        READ(5,1,END=100) K,WORKK
        IF(K.EQ.9999) GO TO 100
        NBC(K)=WORKK(1)
        NBUSM(K)=WORKK(2)
        NOVLD(K)=WORKK(3)
        NBUS=NBUS+1
        IF(CODE.EQ.BLANK) GO TO 95
        WRITE(6,1006 ) K,NBC(K),NBUSM(K),NOVLD(K)
        GO TO 95
100     CONTINUE
        IF(RCODE.EQ.BUSX.AND.NTIMT.NE.0) GO TO 161
1011    CONTINUE
        IF(CODE.NE.BLANK) WRITE(6,6667)  (ATYPE(J),J=1,NTYPE)
```

TABLE 1 CONTINUED

```
6667  FORMAT('0     PT NO ',18(A4,1X))
      NKID=0
C  ***************************************************************************
C     ZERO TOTAL NUMBER IF KIDS BY TYPE
      DO 105 J=1,NTYPE
105   NTKID(J)=0
C  ***************************************************************************
C
C     READ POINT NUMBER AND NUMBER OF DIFFERENT TYPES OF KIDS AT EACH
C     POINT.  READ UNTIL A (/*) CARD IS ENCOUNTERED
C     ***************************************************************
C
110   NN=1
113   READ(5,1,END=120)  MPT,       (MTYPE(NN,K),K=1,NTYPE)
      IF(MPT.EQ.9999) GO TO 120
115   DO 117 J=1,NTYPE
      NKID=NKID+MTYPE(NN,J)
117   NTKID(J)=NTKID(J)&MTYPE(NN,J)
      MPTN(NN)=MPT
      NML(NN)=0
      NREL(NN)=0
      NN=NN&1
      IF(CODE.EQ.BLANK) GO TO 113
      WRITE(6,1006)MPT,(MTYPE(NN-1,K),K=1,NTYPE)
      GO TO 113
C
C  ***************************************************************************
C     READ A POINT NUMBER WITH ALL POINTS (LMAT) THAT IS POSSIBLE
C     TO GO TO FROM THE POINT AND THE ASSOCIATED DISTANCE (MLINK).
C     READ UNTIL A (/*) CARD IS ENCOUNTERED
C     ***************************************************************
C
120   CONTINUE
      IF(RCODE.EQ.KIDSX.AND.NTIMT.NE.0) GO TO 161
1012  CONTINUE
      NCK=0
      NPTS=NN-1
      NPL=1
125   READ(5,1,END=180)  MPT,(NACC(J),MACC(J),J=1,7)
      IF(MPT.EQ.9999) GO TO 180
127   CALL LOOKUP(MPT,NPTS,NC)
      IF(NC-1)133,125,133
133   CONTINUE
      IF(MPT-NCK)130,140,130
130   NN=1
      NREL(MPT)=NPL
      NCK=MPT
      NML(MPT)=0
140   DO 160 J=1,7
      IF(NACC(J))150,160,150
150   CALL LOOKUP (NACC(J),NPTS,NC)
      IF(NC-1)134,160,134
```

TABLE 1 CONTINUED

```
134   CONTINUE
      LMAT(NPL)=NACC(J)
      MLINK(NPL)=MACC(J)
      NML(NCK)=NN
155   NPL=NPL&1
      NN=NN&1
160   CONTINUE
      GO TO 125
C
C     ***************************************************************
C
C     WRITE DATA FOR USE IN PRINT PROGRAM AND WRITE CHECK DATA IF DESIRED
C
C     ***************************************************************
C
180   CONTINUE
      WRITE(1,2222) NPTS,NBUS,NSST,NEND,NTYPE,ATYPE
      WRITE(1,2225) NBC,MPTN,NREC,MTYPE
2225  FORMAT(40A2)
2222  FORMAT(5A2,5A4)
C
      IF(CODE.EQ.BLANK) GO TO 161
C     PRINT LMAT AND MLINK MATRIX  ***********************************
1005  FORMAT('0'25I5)
      WRITE(6,5)
      WRITE(6,6668)
6668  FORMAT(' LMAT AND MLINK MATRIX'//)
      DO 1000 J=1,NPTS
      IF(NML(J).NE.0) GO TO 962
      WRITE(6,1005) MPTN(J)
      GO TO 1000
962   CONTINUE
      KA=NREL(J)
      KB=KA&NML(J)-1
      WRITE(6,1005) MPTN(J),(MPTN(LMAT(LL)),LL=KA,KB)
      WRITE(6,1006) (MLINK(LL),LL=KA,KB)
1006  FORMAT(1H 5X,24I5)
1000  CONTINUE
C
C     ***************************************************************
C
161   CONTINUE
C
      WRITE(6,5)
1611  CONTINUE
C
C  ***************************************************************
C
C                                                    NUMBER OF PTS. NOT
C                        NUMBER  NUMBER  NUMBER ROUTES  SHIFTED AT END OF  RT.
C                        POINTS  BUSSES  TO CONSIDER    IF BLANK ASSUME 1
      READ(5,1,END=302)    N,     LBUS,      NRTC,          NPTD
```

TABLE 1 CONTINUED

```
      IF(N.EQ.9999) GO TO 302
C
CC    ***************************************************************
C
      IF(NPTD.EQ.0) NPTD=1
      IF(CODE.NE.BLANK) WRITE(6,6610) N, LBUS,NRTC,NPTD
6610  FORMAT('      N LBUS NRTC NPTD'/' '4I5)
      IF(CODE.NE.BLANK) WRITE(6,6669)
6669  FORMAT('0      PT NO      ST PT       TIME        SRT      TKIDS')
C
CC    ***************************************************************
C
C     READ SUGGESTED ROUTE - ARRANGED MANUALLY FROM MAP OBSERVATIONS AND
C     LMAT AND MLINK MATRIX, IT MUST BE POSSIBLE TO GO FROM ONE POINT
C     TO THE ONE FOLLOWING IT
C
CC    ***************************************************************
C
      NCK=0
      LNPT=0
      NRC=0
      NOUT=0
      NTKIDD=0
      MAXM=0
      J=0
      RT=0
      NKD=0
      NPTC=1
      LINE=0
C
CC    ***************************************************************
C
C                                                    NUMBER OF STUDENTS AT
C             READ       POINT      POSSIBLE        THIS POINT. LEAVE BLANK IF
C                                   STARTING PTS.   SAME AS READ IN AT START
C                                                   (KTYPE(JL),JL=1,NTYPE)
190   READ(5,1,END=230)  MPT,       NST(NPTC),
      IF(MPT.EQ.9999) GO TO 230
C
CC    ***************************************************************
C
      CALL LOOKUP (MPT,NPTS,NC)
      IF(NC-1)135,193,135
193   NOUT=1
      GO TO 190
135   CONTINUE
      NPTC=NPTC&1
195   LNPT=LNPT&1
      IF(NCK)200,220,2C0
200   CALL SEARCH (NCK,MPT,J)
      IF(J) 210,220,220
210   WRITE(6,3) MPTN(NCK),MPTN(MPT)
      NOUT=1
```

TABLE 1 CONTINUED

```
220   NCK=MPT
      NSUG(LNPT)=MPT
      NSUGW(LNPT)=MPT
      IF(NST(LNPT).EQ.0) GO TO 222
      CALL LOOKUP(NST(LNPT),NPTS,NC)
      IF(NC.EQ.1) GO TO 193
222   CONTINUE
      ISUM=0
      DO 2291 JXK=1,NTYPE
2291  ISUM=ISUM+KTYPE(JXK)
      IF(ISUM.EQ.0) GO TO 221
      DO 2292 JXK=1,NTYPE
2292  MTYPE(MPT,JXK)=KTYPE(JXK)
221   CONTINUE
      NTKIDD=NTKIDD&NKD
      MAXM=MAXM&NTKIDD*J
      CALL AKID(MPT,NKD)
      IF(CODE.EQ.BLANK) GO TO 190
      NPXX=0
      MPX=NST(LNPT)
      IF(MPX.NE.0) NPXX=MPTN(MPX)
      IF(NST(1) .EQ.0) NPXX=MPTN(MPT)
      WRITE(6,1066) MPTN(MPT),NPXX,J,MAXM,NTKIDD
1066  FORMAT(' '5I10)
      GO TO 190
230   CONTINUE
      NPTC=LNPT
      IF(NRTC.EQ.1) GO TO 243
      IF(NTKIDD.LE.NBC(LBUS)+NOVLD(LBUS)) GO TO 243
      WRITE(6,242) NBC(LBUS),NTKIDD,NOVLD(LBUS)
242   FORMAT('0 BUS IS OVERLOADED ON A GENERATED ROUTE ----- BUS CAPACIT
     1Y IS'I5'    TOTAL STUDENTS ------'I5,'     OVERLOAD ---',I5)
      NOUT=1
243   CONTINUE
      IF (NOUT-1)237,232,237
232   WRITE(6,4) LBUS
      IF(NRTC.NE.1) GO TO 161
      GO TO 3011
C
C     ***************************************************************
C
C     THIS SECTION OF THE PROGRAM LOADS A BUS AND PRINTS OUT THE ROUTE
C
C     ***************************************************************
C
237   CONTINUE
      JXY=0
      LNPTS=LNPT-NPTD
      IF(NST(1).NE.0) GO TO 235
      DO 233 J=1,LNPTS
233   NST(J)=NSUG(J)
235   CONTINUE
```

TABLE 1 CONTINUED

```
      DO 234 J=1,LNPTS
      IF(NST(J).EQ.0) GO TO 234
      DO 236 K=1,LNPTS
      IF(NSUG(K).NE.NST(J)) GO TO 236
      GO TO 239
236   CONTINUE
      WRITE(6,2239)
2239  FORMAT(' COULDNT FIND A POINT FROM THE NST MATRIX IN THE NSUG M.')
      GO TO 161
239   NST(J)=K
234   SUBS(J)=J
      IF(CODE.EQ.BLANK) GO TO 231
      WRITE(6,5)
231   CONTINUE
      KKX=0
      NBCPVV=0
      K=1
      IF(NBUSM(LBUS).NE.0) MAXM=NBUSM(LBUS)
C
C     DETERMINE IF THIS IS A GENERATED ROUTE OR NOT
C
      IF(NRTC-1)207,206,207
206   NNBUS=NBUS
      MMAXM=0
      GO TO 208
207   NNBUS=1
208   CONTINUE
      DO 280 J=1,NNBUS
      DO 223 JJ=1,NTYPE
223   KTYPE(JJ)=0
      NBCP=-NBCPVV
      NBCPV=0
      NBCPVV=0
      KK=0
      IF(NRTC-1)203,202,203
202   LBUS=J
203   CONTINUE
240   CALL  AKID(NSUG(K),NKD)
      CALL BUSV(LBUS,NBCP,NKD,NBCPV,M)
      IF(NRTC.NE.1) GO TO 250
      GO TO (250,256,260),M
250   KK=KK&1
      IF(KKX.NE.1) GO TO 241
      NKD=NBCXX
      KKX=0
241   CONTINUE
      NACC(KK)=NSUG(K)
      MACC(KK)=NKD
255   K=K&1
      IF(K-NPTC) 240,270,270
C     OUTPUT ROUTE
256   KK=KK&1
```

TABLE 1 CONTINUED

```
      NACC(KK)=NSUG(K)
      MACC(KK)=NKD-NBCPV
      K=K-1
      KKX=1
      NBCXX=NBCPV
      GO TO 270
260   KK=KK&1
      NACC(KK)=NSUG(K)
      MACC(KK)=NKD
270   CONTINUE
      KK=KK+1
      NACC(KK)=NSUGW(NPTC)
      MACC(KK)=0
      K=K&1
      IF(NRTC.EQ.1) CALL PRINT(LBUS,KK)
      IF(NRTC.GT.1.AND.JXY.NE.0) CALL PRINT(LBUS,KK)
      MMAXM=MMAXM+MILE
      IF(K-NPTC) 280,300,300
280   CONTINUE
300   CONTINUE
      IF(NRTC.EQ.1) GO TO 301
      IF(NRC.GT.NRTC)GO TO 301
      CALL SHIFT(LNPTS)
      DO 238 JXXY=1,LNPTS
      KL=SUBS(JXXY)
238   NSUG(JXXY)=NSUGW(KL)
      IF(JXY.NE.3) GO TO 231
301   CONTINUE
      IF(NRTC.NE.1) GO TO 161
      WRITE(6,128) NKID
128   FORMAT('0 TOTAL STUDENTS IN THIS SYSTEM ---'I8)
      WRITE(6,310) LBUS,NTKIDD,MMAXM,RT
310   FORMAT('0 TOTAL BUSSES USED ---'I3'   TOTAL STUDENTS ---'I4'  STUD
     1ENT RIDING TIME ---'I8'   ROUTE TIME ---'I5)
3011  CONTINUE
      NTIMT=1
      IF(RCODE.EQ.BLANK) GO TO 161
      IF(RCODE.EQ.LMATX) GO TO 1012
      WRITE (6,5)
      IF(RCODE.EQ.BUSX) GO TO 9055
      IF(RCODE.EQ.KIDSX) GO TO 1011
      GO TO 9011
302   CONTINUE
      ENDFILE 1
      ENDFILE 2
C     END OF MAIN LINE PROGRAM
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE LOOKUP(K,NPTS,NC)
      IMPLICIT INTEGER*2(A-Z)
      INTEGER*4 NRC,MAXM,MILE,MMAXM
      INTEGER*4 ATYPE
C     ****************************************************************************
C
C     SUBROUTINE TO LOOKUP A POINT IN THE MPTN MATRIX AND ASSIGN IT A
C     NUMBER IN NUMERICAL ORDER
C
C     ****************************************************************************
      DIMENSION ATYPE(5),NBC(50),MPTN(150),MTYPE(150,5),NTKID(5),
     1NSUG(150),NACC(52),MACC(52),LMAT(1500),MLINK(1500),NML(150),
     2NREL(150),LACC(52),KTYPE(5),NBUSM(50),NSUGW(150),NOVLD(50),
     3NST(150),SUBS(150)
C
      COMMON    NRC,MAXM,MILE,MMAXM
      COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
      COMMON LACC,NACC,MACC
      COMMON NTYPE,NML,NRTC,LINE
      COMMON RT,NBUSM
      COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
C
1     FORMAT(1H I5,2X,15HIS NOT IN TABLE)
2     FORMAT(I5)
      NC=0
101   DO 100 J=1,NPTS
      IF(MPTN(J)-K)100,102,100
100   CONTINUE
      WRITE(6,1) K
      NC=1
102   K=J
      RETURN
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE SEARCH(J,K,L)
      IMPLICIT INTEGER*2(A-Z)
      INTEGER*4 NRC,MAXM,MILE,MMAXM
      INTEGER*4 ATYPE
C
C
C     SUBROUTINE TO SEARCH THE LMAT MATRIX FOR A POINT AND THEN
C     GO TO THE MLINK MATRIX AND GET THE TIME REQUIRED TO GO TO THAT POINT
C
C     ***************************************************************************
      DIMENSION ATYPE(5),NBC(50),MPTN(150),MTYPE(150,5),NTKID(5),
     1NSUG(150),NACC(52),MACC(52),LMAT(1500),MLINK(1500),NML(150),
     2NREL(150),LACC(52),KTYPE(5),NBUSM(50),NSUGW(150),NOVLD(50),
     3NST(150),SUBS(150)
C
      COMMON    NRC,MAXM,MILE,MMAXM
      COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
      COMMON LACC,NACC,MACC
      COMMON NTYPE,NML,NRTC,LINE
      COMMON RT,NBUSM
      COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
C
      L=-1
      JA=NREL(J)
      KA=JA&NML(J)-1
      IF(KA.LT.JA) GO TO 102
      DO 100 JL=JA,KA
      IF(LMAT(JL)-K)100,101,100
100   CONTINUE
      GO TO 102
101   L=MLINK(JL)
102   RETURN
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE AKID(K,NKD)
      IMPLICIT INTEGER*2(A-Z)
      INTEGER*4 NRC,MAXM,MILE,MMAXM
      INTEGER*4 ATYPE
C     ************************************************************
C
C
C     SUBROUTINE TO TOTAL THE DIFFERENT TYPES  OF CHILDREN AT A POINT
C
C     ************************************************************
      DIMENSION ATYPE(5),NBC(50),MPTN(150),MTYPE(150,5),NTKID(5),
     1NSUG(150),NACC(52),MACC(52),LMAT(1500),MLINK(1500),NML(150),
     2NREL(150),LACC(52),KTYPE(5),NBUSM(50),NSUGW(150),NOVLD(50),
     3NST(150),SUBS(150)
C
      COMMON    NRC,MAXM,MILE,MMAXM
      COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
      COMMON LACC,NACC,MACC
      COMMON NTYPE,NML,NRTC,LINE
      COMMON RT,NBUSM
      COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
C
      NKD=0
      DO 100 JA=1,NTYPE
      NNN=MTYPE(K,JA)
      KTYPE(JA)=KTYPE(JA)&NNN
100   NKD=NKD&NNN
      RETURN
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE BUSV(J,NBCP,NKD,NBCPV,M)
      IMPLICIT INTEGER*2(A-Z)
      INTEGER*4 NRC,MAXM,MILE,MMAXM
      INTEGER*4 ATYPE
C     ***************************************************************************
CC
C
C     SUBROUTINE TO LOAD THE CHILDREN AT A POINT ON A BUS
C
C     ***************************************************************************
      DIMENSION ATYPE(5),NBC(50),MPTN(150),MTYPE(150,5),NTKID(5),
     1NSUG(150),NACC(52),MACC(52),LMAT(1500),MLINK(1500),NML(150),
     2NREL(150),LACC(52),KTYPE(5),NBUSM(50),NSUGW(150),NOVLD(50),
     3NST(150),SUBS(150)
C
      COMMON    NRC,MAXM,MILE,MMAXM
      COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
      COMMON LACC,NACC,MACC
      COMMON NTYPE,NML,NRTC,LINE
      COMMON RT,NBUSM
      COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
C
      M=1
      IF(NBCP&NKD-NBC(J))100,103,200
200   IF(NBCP&NKD-(NBC(J)&NOVLD(J)))103,103,102
102   NBCPV=NBCP&NKD-(NBC(J)&NOVLD(J))
      NBCPVV=NKD-NBCPV
      NBCP=NBC(J)&NOVLD(J)
      M=2
      GO TO 203
103   M=3
100   NBCP=NBCP&NKD
203   RETURN
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE SHIFT(NPTS)
      IMPLICIT INTEGER*2 (A-Z)
      DIMENSION NC(150)
      DIMENSION NST(150),SUBS(150),NSUGW(150),LMAT(1500),MLINK(1500)
      COMMON/ABC/ LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK
      J=NPTS
      IF(JXY.EQ.1) GO TO 111
      JXY=1
      NSTT=0
160   NSTT=NSTT+1
      IF(NSTT.GT.NPTS)GO TO 150
      SUBS(1)=NST(NSTT)
      DO 100 K=1,NPTS
100   NC(K)=0
      NC(SUBS(1))=1
      J=1
      GO TO 75
111   J=J-1
      IF(J.LE.1) GO TO 160
      DO 112 K=J,NPTS
112   NC(SUBS(K))=0
50    SUBS(J)=SUBS(J)+1
      IF(SUBS(J).GT.NPTS) GO TO 111
      IF(NC(SUBS(J)).NE.0) GO TO 50
      CALL SEARCH(NSUGW(SUBS(J-1)),NSUGW(SUBS(J)),ICK)
      IF(ICK.LT.0) GO TO 50
      NC(SUBS(J))=1
75    CONTINUE
      JJ=J
      DO 175 K=1,NPTS
      IF(NC(K).NE.0) GO TO 175
      NC(K)=1
      JJ=JJ+1
      SUBS(JJ)=K
      CALL SEARCH(NSUGW(SUBS(JJ-1)),NSUGW(SUBS(JJ)),ICK)
      IF(ICK.GT.0) GO TO 175
      DO 1175 JK=1,NPTS
1175  NC(JK)=0
      J=JJ-1
      DO 1176 JK= 1,J
1176  NC(SUBS(JK))=1
      J=JJ
      GO TO 50
175   CONTINUE
      RETURN
150   CONTINUE
      JXY=3
      RETURN
      END
```

TABLE 1 CONTINUED

```
      SUBROUTINE PRINT (NJ,KK)
      IMPLICIT INTEGER*2(A-Z)
      INTEGER*4 NRC,MAXM,MILE,MMAXM
      INTEGER*4 ATYPE
      ************************************************************************

      SUBROUTINE TO PRINT A BUS ROUTE

      ************************************************************************
      DIMENSION ATYPE(5),NBC(50),MPTN(150),MTYPE(150,5),NTKID(5),
     1NSUG(150),NACC(52),MACC(52),LMAT(1500),MLINK(1500),NML(150),
     2NREL(150),LACC(52),KTYPE(5),NBUSM(50),NSUGW(150),NOVLD(50),
     3NST(150),SUBS(150)

      COMMON    NRC,MAXM,MILE,MMAXM
      COMMON MPTN,NTOT,NREL,NSST,MTYPE,KTYPE,NBC,NOVLD,NBCPVV
      COMMON LACC,NACC,MACC
      COMMON NTYPE,NML,NRTC,LINE
      COMMON RT,NBUSM
      COMMON /ABC/LNPTS,JXY,NST,SUBS,NSUGW,LMAT,MLINK

C
33    FORMAT(1H026I5)
3     FORMAT(1H 26I5)
4     FORMAT(1H )
5     FORMAT(1H 11HCANNOT FIND ,I5,3H TO,I5)
      NRC=NRC&1
      MILE=0
      NRT=0
      NTKD=MACC(1)
      DO 1C0 J=2,KK
      CALL SEARCH(NACC(J-1),NACC(J),L)
      IF(L)201,202,202
201   CONTINUE
      IF(NRTC.NE.1) GO TO 102
      WRITE(6,5) MPTN(NACC(J-1)), MPTN(NACC(J))
      GO TO 102
202   CONTINUE
      LACC(J)=L
      MILE=MILE&NTKD*L
      IF(NRTC.EQ.1) GO TO 101
      IF(MILE-MAXM)101,101,102
101   NRT=NRT&L
      RT=RT+L
100   NTKD=NTKD&MACC(J)
      NSSTT=NSST-NSST/100*40
      NL=NSSTT-NRT
      LACC(1)=NL/60*40&NL
      DO 200 J=2,KK
      NL=NL&LACC(J)
      LACC(J  ) =NL/60*40&NL
200   CONTINUE
2     FORMAT('OBUS NO. 'I3'  NUMBER OF STUDENTS 'I4'  ROUTE TIME 'I4'  S
     1TUDENT RIDING TIME 'I8'  GENERATION NO. 'I5)
```

TABLE 1 CONTINUED

```
22    FORMAT(' BUS NO. 'I3'  NUMBER OF STUDENTS 'I4'  ROUTE TIME 'I4'  S
     1TUDENT RIDING TIME 'I8'  GENERATION NO. 'I5)
      KX=KK/26+1
      WRITE(2,2222) NJ,NTKD,NRT,MILE,NRC
2222  FORMAT(3A2,2A4)
      WRITE(2,2223) MACC,NACC,LACC
2223  FORMAT(40A2)
      DO 300 JX=1,KX
      JXX=JX*25-25+1
      JYY=1/JX*(KK-KK/25*KK+KK/25*25)+JX/2*KK
      WRITE(6,33)(MACC(J),J=JXX,JYY)
      WRITE(6,3) (MPTN(NACC(J)),J=JXX,JYY)
      WRITE(6,3) (LACC(J),J=JXX,JYY)
      WRITE(6,22)NJ,NTKD,NRT,MILE,NRC
      WRITE(6,4)
      LINE=LINE+1
      IF(LINE.NE.10) GC TO 300
      LINE=0
      WRITE(6,10)
10    FORMAT('1')
300   CONTINUE
C*****************************************************************
C     ZERO MACC NACC , AND LACC
C
102   DO 700 I=1,52
      MACC(I)=0
      NACC(I)=0
700   LACC(I)=0
      RETURN
      END
```

CONCLUSIONS

The purpose of this Final Report was to present a FORTRAN computer program that can be used to design school bus routes.

Some of the more general conclusions of this study are as follows:

1. A heuristic solution to the school bus routing problem seems to be a satisfactory one at this time.

2. Many field tests of the computer program indicate that school bus routes can be designed that are as short or shorter than routes designed by hand. Therefore, the computer technique may offer a greater saving of time than financial savings for transportation directors.

3. Because the amount of computer time required to design routes will vary according to school district, no time estimates will be given.

4. It is absolutely necessary for anyone planning to use the school bus routine program to secure a copy of the User's Manual presented in Appendix A. This manual must be studied very carefully, and based on recommendations of current users of the program, the prospective user may find it necessary to contact the director to discuss in detail the manual, preparation of input data, and the actual FORTRAN program.

5. The program presented seems to be a very useful tool in designing of school bus routes; but as in any new development, some difficulties will be encountered in the initial use of the program. After one or two small areas of a school system have been computerized, complete change over from manual to computer routing should be easier, relatively simple, and a straightforward procedure.

6. The present computer program is being revised constantly, and any person contemplating the use of it should contact the Director if he wants the benefit of the latest development.

REFERENCES

Boyer, R. A., The Use of Mathematical Programming to Solve Certain Problems in Public School Transportation, Cooperative Research Project 783, University of Mississippi, 1961.

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APPENDIX A

USER'S MANUAL

USER'S MANUAL FOR A FORTRAN PROGRAM TO DESIGN SCHOOL BUS ROUTES
1968 Edition

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Bureau of Research

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SECTION A

INTRODUCTION

The School Bus Routing Program was developed by the University of Mississippi to aid transportation directors to design efficient school bus routes.

This manual is a guide for the preparation of data to be used in the program. The topics discussed include: collecting data, procedures to be used in suggesting routes, and preparing different combinations of the suggested routes.

SECTION B

COLLECTION OF INITIAL DATA

Three types of data are required in the school bus computer program: stop numbers, the "KIDS Matrix," and the "LMAT-MLINK Matrix." Each of these types of data is described in the following paragraphs:

1. Stop Numbers

Each stop or pick up point in the school system must be assigned a stop number. The location of each stop may be described in terms of street addresses or local landmarks. The school site is also assigned a stop number. (See Table 1 for a sample list of stop numbers and addresses.)

2. KIDS Matrix

The KIDS Matrix is a list of stop numbers and the number of students at each stop. For example, if there are two elementary students, one junior high student, and five senior high students at stop number 100, the Kids Matrix entry would be the following:

100 2 1 5

When a bus is being loaded, the number of students loaded depends on the number of students specified in the Kids Matrix (See Table 2 for sample KIDS Matrix.)

Table 1

1	2
01	13418 7 1/2 MILE RD
02	13324 7 1/2 MILE RD
03	13032 7 1/2 MILE RD
04	12502 7 1/2 MILE RD
05	12400 7 1/2 MILE RD
06	12006 7 1/2 MILE RD
07	HWY 38 + 7 1/2 MILE RD
08	8049 HWY 41
09	7 MILE RD + HAGEMANN RD
10	12813 7 MILE RD
11	12329 7 MILE RD
12	8123 HY 38
13	10207 7 MILE RD
14	9807 7 MILE RD
15	9326 7 MI RD + NICHOLSON RD
16	8510 7 MILE RD
17	7920 7 MILE RD
18	13410 6 1/2 MILE RD
19	13116 6 1/2 MILE RD
20	12926 6 1/2 MILE RD
21	12500 6 1/2 MILE RD
22	7600 HWY V
23	11026 6 1/2 MILE RD
24	7153 HWY 41
25	6601 HWY V
26	11933 HY G
27	11001 HWY G
28	10612 HWY G
29	13500 BELL RD
30	13131 BELL RD
31	8348 HY 38
32	HWY 38 AND FOREST HILL RD
33	6237 HY H
34	5955 HWY V
35	5544 HWY V
36	8645 EAU GALLE RD
37	7826 HWY V
38	6205 HWY V
39	8405 NICHOLSON RD
40	CADDY VISTA SCHOOL

Stop Numbers and Addresses

1. Stop Numbers
2. Addresses

Table 2

PT NO	ELEM	JR	SR
1	6	0	0
2	5	0	0
3	8	0	0
4	10	0	0
5	2	0	0
6	10	0	0
7	1	0	0
8	7	0	0
9	18	0	0
10	1	0	0
11	4	0	0
12	2	0	0
13	10	0	0
14	4	0	0
15	1	0	0
16	7	0	0
17	3	0	0
18	1	0	0
19	6	0	0
20	1	0	0
21	2	0	0
22	5	0	0
23	1	0	0
24	1	0	0
25	2	0	0
26	5	0	0
27	1	0	0
28	3	0	0
29	5	0	0
30	1	0	0
31	3	0	0
32	3	0	0
33	2	0	0
34	15	0	0
35	9	0	0
36	15	0	0
37	4	0	0
38	3	0	0
39	1	0	0
40	0	0	0

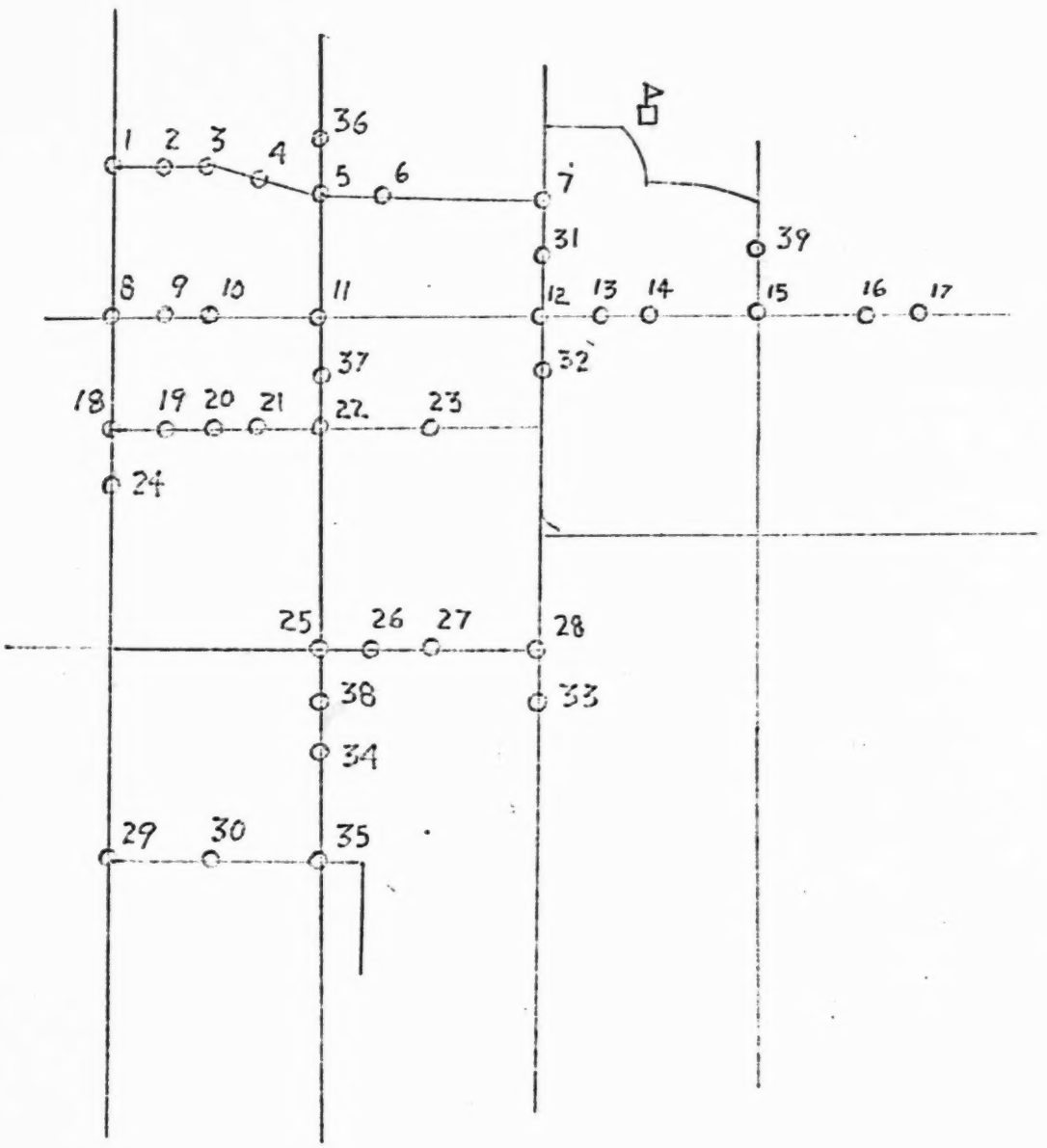
Sample KIDS Matrix

1. Point number

2. Number of Elementary, Junior High and Senior High students at each point

3. LMAT and MLINK Matrix

The LMAT and MLINK matrix is used to provide the school bus routing program with information concerned with traveling from one point to another point. For every point in the school system the LMAT matrix provides a list of the points to which a bus can go if it is at any given point. The MLINK matrix provides a list of the times required to travel between the points given in the LMAT matrix. When the LMAT and MLINK matrix is prepared, all possible points to which a bus can go from each point in the school system should be included; and the time between points should be as accurate as possible. The reasons for the former statement are: (1) When routes are being generated, a route is abondoned when it is not possible for a bus to travel from one point to another according to the LMAT matrix, and (2) Variations in the time required to travel between points could cause a poor bus route to have a short route time or cause a good bus route to have a long route time. Using the map in Figure 1 and the LMAT and MLINK matrix in Table 3, it can be seen that from point 1 a bus can travel to points 2,8,10, and 40. However, a bus cannot travel to points 3,4,5,6 etc., using the data given in LMAT and MLINK matrix.



Legend: ○ Bus stop

□ Caddy Vista School

Figure 1. Map from Unified School District Number 1, Racine, Wisconsin.

Table 3

(1)	(2)	(3)	(2)	(3)	(2)	(3)	(2)	(3)					
01	02	01	08	03	40	11	10	05					
02	01	01	03	01	40	10							
03	02	01	04	01	40	09							
04	03	01	05	01	40	08	36	02					
05	04	01	06	01	36	01	11	02	40	07			
06	05	01	07	03	40	06	36	02					
07	06	03	31	01	13	03	40	03					
07	36	05											
08	01	03	09	01	18	02	40	14	24	03	10	02	
09	08	01	10	01	40	12							
10	09	01	11	02	40	11	01	05	18	04			
11	10	02	12	04	37	01	05	02	40	09			
11	31	05											
12	11	04	13	01	31	01	32	01	40	05			
13	12	01	14	01	40	06	23	05	07	03			
13	31	02											
14	13	01	15	02	40	07	39	03	17	04			
15	14	02	39	01	16	02	40	05					
16	15	02	17	01	40	07	39	03					
17	16	01	15	03	40	08							
18	08	02	19	01	24	01	40	16	10	04			
19	18	01	20	01	40	17							
20	19	01	21	01	40	13							
21	20	01	22	01	40	12	37	02					
22	21	01	37	01	23	02	25	04	40	11			
23	37	03											
23	22	02	32	03	28	06	40	09					
24	18	01	25	07	29	07	40	16	08	03			
24	10	05											
25	24	07	26	01	38	01	22	04	29	08	40	15	
26	25	01	27	01	40	14							
27	26	01	28	02	40	13	33	03					
28	27	02	33	01	32	05	23	06	15	10	17	15	40	11
29	24	07	25	08	40	23	30	02					
30	29	02	35	02	40	21							
31	07	01	12	01	40	04							
31	13	02											
31	37	03											
31	36	06	11	05									
32	12	01	23	03	28	05	33	16	40	06			
33	28	01	40	12	27	03							
34	38	01	35	02	40	17							
35	34	02	30	02	40	19							
36	05	01	40	08	04	02	06	02					
37	11	01	22	01	40	10	23	03	21	02			
38	25	01	34	01	40	16							
39	15	01	40	04	14	03	16	03	17	04			

Sample LMAT and MLINK Matrix

1. Beginning Point number
2. Point to which a bus can travel from the beginning point
3. Time required to travel from the beginning point to the corresponding point with a column header of 2

SECTION C

SUGGESTED ROUTES

Once the initial data has been collected, a manually arranged route must be prepared. This route is prepared by designing a bus route that passes every point in the school system as though only one bus would be used to transport all of the students in the system. When this route is used as input data, the program divides the route into several smaller routes using the bus capacities specified in the input data for the program. By varying the order of the busses, if all the busses are not the same capacity, different sets of routes can be prepared. These suggested routes are then input for generating routes, which will be discussed later.

In the following paragraphs the input data and output data associated with suggesting routes is discussed. The input data is presented in the order in which it is read by the computer.

1. Specifying the Types of Students

The first input card specifies the number of types of students in the school system and the abbreviated name for each type of student (see Table 4 for sample input card).

2. Bus Capacities

The second set of data consists of the bus numbers, their capacities, the maximum student riding time for each bus, and the overload for each bus. The capacity of the bus plus the overload is used in determining where one bus route ends and another begins. If the overload is left blank or is 0, no overload is assumed for the bus.

If the maximum student riding time if left blank, it is assumed to be the route time computed from the first route. The route will be terminated when the maximum student riding time is reached, even though the bus is not completely filled. (See table 5 for sample bus capacities)

3. KIDS Matrix

See "KIDS Matrix" on page 4.

4. LMAT and MLINK Matrix

See "LMAT and MLINK Matrix" on page 7.

5. Manually Arranged Route

(a) Header Card

The header card for the manually arranged route contains the school point number, the number of busses to be used, and the number of generations to be considered. For manual routes, the number of generations to be considered is always one. (See table 6 for a sample header card)

(b) Points in the Suggested Route

Each header card is followed by a manually arranged set of stop numbers. The manually arranged route is discussed in the opening paragraph of this section. (See table 6 for a sample route)

6. Suggested Route Output

The manually arranged route is divided into several smaller suggested routes using the busses provided and these suggested

routes are printed. The output consists of the number of students loaded at each point, the point numbers, the arrival time of the bus at each point, the bus number, the number of students riding the bus, the route time, the student riding time, and the generation number. For a suggested route, the generation number is irrelevant (See Table 7 for sample output from suggesting routes).

After the suggested routes have been printed, each route must be checked for logical ending points and split points Decisions then have to be made about what changes must be made in the suggested routes. By looking at the routes in Table 7, one can see that points 8 and 34 have been split. By increasing the capacity of bus number 1 to 67 and decreasing the capacity of bus number 2 to 65, all of the students at point number 8 can be transported by bus number 1. All of the students at point number 34 can be transported by bus number 3 by decreasing the capacity of bus number 2 to 58 and increasing the capacity of bus number 3 to 63. The changes required to prepare generated routes from the suggested routes in Table 7 are are summarized in Table 8.

Table 4

Sample Input for Specifying the Types of Students

1. Number of types of students in school system
2. Four letter abbreviated name for each type of student

Table 5

Bus No.	CAP	MSRT	OVLD
1	66	0	0
2	66	0	0
3	66	0	0

Sample Bus Capacities

1. Bus number
2. Bus capacity
3. Maximum student riding time
4. Overload

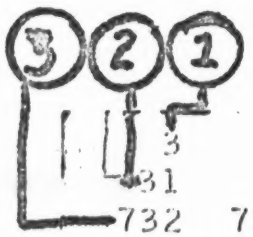
Table 6

(1)	(2)	(3)
40	03	01

(4)
31
07
06
05
36
04
03
02
01
08
09
10
11
37
22
21
20
19
18
24
29
30
35
34
38
25
26
27
33
28
23
32
12
13
14
15
39
16
17
40

Manually Arranged Route

1. School point
2. Number of buses
3. Number of generations (always 1 for manual routes)
4. Points in the suggested route




```
  3    1   10    2   15   10    8    5    6    6    0
 31    7    6    5   36    4    3    2    1    8   40
732  733  736  737  738  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   66  ROUTE TIME   28  STUDENT RIDING TIME     1355  GENERATION NO.     1

  1   18    1    4    4    5    2    1    6    1    1    5    1    9    7    0
  8    9   10   11   37   22   21   20   19   18   24   29   30   35   34   40
719  720  721  723  724  725  726  727  728  729  730  737  739  741  743  800
BUS NO.   2  NUMBER OF STUDENTS   66  ROUTE TIME   41  STUDENT RIDING TIME     2047  GENERATION NO.     2

  8    3    2    5    1    2    3    1    3    2   10    4    1    1    7    3    0
 34   38   25   26   27   33   28   23   32   12   13   14   15   39   16   17   40
725  726  727  728  729  732  733  739  742  743  744  745  747  748  751  752  800
BUS NO.   3  NUMBER OF STUDENTS   56  ROUTE TIME   35  STUDENT RIDING TIME     1217  GENERATION NO.     3

TOTAL STUDENTS IN THIS SYSTEM ---     188

TOTAL BUSSES USED ---  3   TOTAL STUDENTS --- 188  STUDENT RIDING TIME ---    4619   ROUTE TIME ---  104
```

Sample Output of Suggested Routes

1. Number of students loaded on the bus at each point
2. Point number
3. Arrival time of the bus at each point

3	1	10	2	15	10	8	5	6	7/8	0					
31	7	6	5	36	4	3	2	1	8	40					
732	733	736	737	738	740	741	742	743	746	800					

BUS NO. 1 NUMBER OF STUDENTS ~~66~~ 67 ROUTE TIME 28 STUDENT RIDING TIME 1355 GENERATION NO. 1

~~1~~	18	1	4	4	5	2	1	6	1	1	5	1	9	~~7~~	0
~~3~~	9	10	11	37	22	21	20	19	18	24	29	30	35	~~34~~	40
~~719~~	720	721	723	724	725	726	727	728	729	730	737	739	741	~~743~~	800

BUS NO. 2 NUMBER OF STUDENTS ~~66~~ 58 ROUTE TIME 41 STUDENT RIDING TIME 2047 GENERATION NO. 2

15/8	3	2	5	1	2	3	1	3	2	10	4	1	1	7	3	0
34	38	25	26	27	33	28	23	32	12	13	14	15	39	16	17	40
725	726	727	728	729	732	733	739	742	743	744	745	747	748	751	752	800

BUS NO. 3 NUMBER OF STUDENTS ~~56~~ 63 ROUTE TIME 35 STUDENT RIDING TIME 1217 GENERATION NO. 3

TOTAL STUDENTS IN THIS SYSTEM --- 188

TOTAL BUSSES USED --- 3 TOTAL STUDENTS --- 188 STUDENT RIDING TIME --- 4619 ROUTE TIME --- 104

Revised Suggested Routes

SECTION D

GENERATED ROUTES

The final phase of preparing school bus routes is generating all possible combinations of the suggested routes prepared in the previous step. This phase consists of trying N combinations of the suggested route, checking each combination for errors caused by not being able to go from one point to the next in the route, and printing all routes which have no errors and a route time less than or equal to the original route time.

In the following paragraphs, the input and output associated with preparing generated routes is discussed.

1. Follow procedures 1-4 for preparing suggested routes.

2. Generated Route Input

   (a) Header Card

   The header card consists of the school point number, the bus number and the number of generations to be considered. (See Table 9 for a sample header card.)

   (b) Suggested Route Prepared by Program

   Each header card is followed by one of the suggested routes prepared earlier. Each suggested route consists of the points in the bus route and the points which are to be considered as starting points. If no starting points are given, all of the points except the last in the suggested route are used as starting points. (See Table 9 for sample data for generating routes.)

3. Generated Route Output

For each generation which meets the conditions stated in the opening paragraph of this section, the number of students loaded at each point, the point numbers in the route, the arrival time of the bus at each route, the bus number, the number of students on the bus, the route time, the student riding time, and the generation number are printed and also stored on a sequential file on tape or disk. (See Table 10 for a sample generated route.)

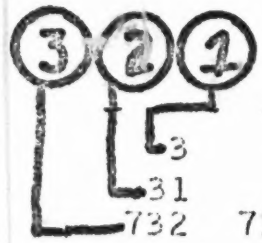
After this phase is complete, the program described in Section E can be used to print selected generations of the routes in a more usable form.

Table 9

	1	2	3
	40	01	200
4	31		
	07		
	06		
	05		
	36		
	04		
	03		
	02		
	01		
	08		
5	40		
	9999		
	40	02	200
	08		
	09		
	10		
	11		
	37		
	22		
	21		
	20		
	19		

Sample Data for Generating Routes

1. School number
2. Bus number
3. Number of generations to be considered
4. Points in the suggested route
5. Trailer card




```
  3    1   10    2   15   10    8    5    6    7    0
 31    7    6    5   36    4    3    2    1    8   40
732  733  736  737  738  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   28  STUDENT RIDING TIME     1369  GENERATION NO.    1

  3    1   10   15    2   10    8    5    6    7    0
 31    7    6   36    5    4    3    2    1    8   40
732  733  736  738  739  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   28  STUDENT RIDING TIME     1365  GENERATION NO.    2

  7    6    5    8   10    2   10    1    3   15    0
  8    1    2    3    4    5    6    7   31   36   40
734  737  738  739  740  741  742  745  746  752  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   26  STUDENT RIDING TIME     1193  GENERATION NO.    7

  7    6    5    8   10    2   15   10    1    3    0
  8    1    2    3    4    5   36    6    7   31   40
742  745  746  747  748  749  750  752  755  756  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   18  STUDENT RIDING TIME      779  GENERATION NO.    8

  7    6    5    8   10   15    2   10    1    3    0
  8    1    2    3    4   36    5    6    7   31   40
742  745  746  747  748  750  751  752  755  756  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   18  STUDENT RIDING TIME      775  GENERATION NO.    9
```

Sample Generated Routes for 1 Bus

1. Number of students loaded at each point
2. Point number
3. Arrival time of bus at each point

SECTION E

PRINTED SELECTED GENERATED ROUTES

The procedures described in this section present a way of printing selected generated routes in table form using the data stored on files 1 and 2 after the routes have been generated. Since this procedure does not generate routes and output must be consistant with local forms, the program is really a "bookkeeping" procedure rather than a research methodology. The printouts in the User's Manual are for illustrative purposes only.

The card input is presented in the following paragraphs in the order in which it may be read by the computer.

1. Number of Copies of Each Route.

The first input card specifies the number of copies of each route to be printed. The number of copies is right justified in the first 5 columns of the card.

2. Bus Capacities.

For each bus used in the system, there is a card with the bus number and the capacity of the bus. The capacity of the bus should be the number of students the bus was designed to hold, not the number of students riding the bus. (See Table 11 for a sample set of bus capacities.)

3. Header Cards.

The header cards contain the information that is printed at the beginning of each bus route. (See Table 12 for a sample set of header cards.)

4. Stop Numbers and Addresses.

See "Stop Numbers" on page 2.

5. Generations to be Printed.

The final set of data contains the information required to select the generations of each route that are to be printed. The data consists of bus number, the school starting time, the school dismissal time, school arrival time, school leaving time, and the numbers of the generations to be printed. A maximum of ten generation numbers can appear on a card. (See Table 13 for a sample set of data.)

The output from the program consists of the following: the headers used as input, the route number, the generation number, the route time, the number of students transported, the bus capacity, the student riding time, the school starting time, the school dismissal time, the school arrival time time, the school leaving time, the stops on the route and their addresses, the arrival time of the bus at each stop in the morning and afternoon, and the number of each type of student at each stop. (See Table 14 for a sample route.)

Table 11

1	2
01	66
02	66
03	66

Sample Bus Numbers and Capacities
for Printing Selected Generated Routes

Table 12

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

Sample Header Cards

Table 13

1	2	3	4	5	6
01	0800	0300	0750	0305	09
02	0800	0300	0750	0305	02
03	0800	0300	0750	0305	10

Sample Data for Selecting Generations to be Printed

1. Bus number
2. School starting time
3. School ending time
4. School arrival time
5. School leaving time
6. Generation numbers to be printed (10 generation numbers can be on one card).

Table 14

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

BUS NUMBER -----		DRIVER ----------	
ROUTE NUMBER 1	GENERATION 9	ROUTE TIME	18
NO. TRANSPORTED 67	BUS CAP. 66	STUDENT TIME	775
SCHOOL STARTING TIME 8.00 A.M.		SCHOOL DISMISSAL TIME	3.00 P.M.
SCHOOL ARRIVAL TIME 7.50 A.M.		SCHOOL LEAVING TIME	3.05 P.M.

POINT	ADDRESS	A.M. ARRIVAL TIME	P.M.	NO. OF STUDENTS ELEM	JR	SR
8	8049 HWY 41	7.32	3.23	7		
1	13418 7 1/2 MILE RD	7.35	3.20	6		
2	13324 7 1/2 MILE RD	7.36	3.19	5		
3	13032 7 1/2 MILE RD	7.37	3.18	8		
4	12502 7 1/2 MILE RD	7.38	3.17	10		
36	8645 EAU GALLE RD	7.40	3.15	15		
5	12400 7 1/2 MILE RD	7.41	3.14	2		
6	12006 7 1/2 MILE RD	7.42	3.13	10		
7	HWY 38 & 7 1/2 MILE RD	7.45	3.10	1		
31	8348 HY 38	7.46	3.09	3		
40	CADDY VISTA SCHOOL	7.50	3.05			

Sample Output from Printing Selected
Generated Routes

SECTION F

SAMPLE DATA FOR A SCHOOL SYSTEM

This section contains a complete set of data for preparing school bus routes for Racine, Wisconsin.

Pages 20-22 contain a list of all the data required to produce the suggested routes on page 23. Page 24 contains the suggested routes with the changes required to generate routes. The data required to generate the routes is listed on pages 25-27, and the generated routes are listed on pages 28-30.

The data listed on page 35 is used to print the routes on pages 36-38 using the information about the generated routes on pages 27-29.

All input data is punched using 5 digit fields and the numbers are right justified in these fields. The first header card is the only exception and is punched as follows:

Field 1 -- Right justified in 5 digit field.

Field 2, 3, 4, etc. -- Centered in 4 column field with 1 blank between each field.

```
  03ELEM  JR   SR
  01   66
  02   66
  03   66
9999
  01   006
  02   005
  03   008
  04   010
  05   002
  06   010
  07   001
  08   007
  09   018
  10   001
  11   004
  12   002
  13   010
  14   004
  15   001
  16   007
  17   003
  18   001
  19   006
  20   001
  21   002
  22   005
  23   001
  24   001
  25   002
  26   005
  27   001
  28   003
  29   005
  30   001
  31   003
  32   003
  33   002
  34   015
  35   009
  36   015
  37   004
  38   003
  39   001
  40
9999
  01   02   01   08   03   40   11   10   05
  02   01   01   03   01   40   10
  03   02   01   04   01   40   09
  04   03   01   05   01   40   08   36   02
  05   04   01   06   01   36   01   11   02   40   07
  06   05   01   07   03   40   06   36   02
  07   06   03   31   01   13   03   40   03
  07   36   05
  08   01   03   09   01   18   02   40   14   24   03   10   02
```

Input for Suggested Routes (Continued)

```
09 08 01 10 01 40 12
10 09 01 11 02 40 11 01 05 18 04
11 10 02 12 04 37 01 05 02 40 09
11 31 05
12 11 04 13 01 31 01 32 01 40 05
13 12 01 14 01 40 06 23 05 07 03
13 31 02
14 13 01 15 02 40 07 39 03 17 04
15 14 02 39 01 16 02 40 05
16 15 02 17 01 40 07 39 03
17 16 01 15 03 40 08
18 08 02 19 01 24 01 40 16 10 04
19 18 01 20 01 40 17
20 19 01 21 01 40 13
21 20 01 22 01 40 12 37 02
22 21 01 37 01 23 02 25 04 40 11
23 37 03
23 22 02 32 03 28 06 40 09
24 18 01 25 07 29 07 40 16 08 03
24 10 05
25 24 07 26 01 38 01 22 04 29 08 40 15
26 25 01 27 01 40 14
27 26 01 28 02 40 13 33 03
28 27 02 33 01 32 05 23 06 15 10 17 15 40 11
29 24 07 25 08 40 23 30 02
30 29 02 35 02 40 21
31 07 01 12 01 40 04
31 13 02
31 37 03
31 36 06 11 05
32 12 01 23 03 28 05 33 16 40 06
33 28 01 40 12 27 03
34 38 01 35 02 40 17
35 34 02 30 02 40 19
36 05 01 40 08 04 02 06 02
37 11 01 22 01 40 10 23 03 21 02
38 25 01 34 01 40 16
39 15 01 40 04 14 03 16 03 17 04
9999
40 03 01
31
07
06
05
36
04
03
02
01
08
09
10
11
37
22
```

```
21
20
19
18
24
29
30
35
34
38
25
26
27
33
28
23
32
12
13
14
15
39
16
17
40
9999
/*
```

```
   3    1   10    2   15   10    8    5    6    6    0
  31    7    6    5   36    4    3    2    1    8   40
 732  733  736  737  738  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   66  ROUTE TIME   28  STUDENT RIDING TIME     1355  GENERATION NO.     1

   1   18    1    4    4    5    2    1    6    1    1    5    1    9    7    0
   8    9   10   11   37   22   21   20   19   18   24   29   30   35   34   40
 719  720  721  723  724  725  726  727  728  729  730  737  739  741  743  800
BUS NO.   2  NUMBER OF STUDENTS   66  ROUTE TIME   41  STUDENT RIDING TIME     2047  GENERATION NO.     2

   8    3    2    5    1    2    3    1    3    2   10    4    1    1    7    3    0
  34   38   25   26   27   33   28   23   32   12   13   14   15   39   16   17   40
 725  726  727  728  729  732  733  739  742  743  744  745  747  748  751  752  800
BUS NO.   3  NUMBER OF STUDENTS   56  ROUTE TIME   35  STUDENT RIDING TIME     1217  GENERATION NO.     3

TOTAL STUDENTS IN THIS SYSTEM ---    188

TOTAL BUSSES USED ---  3  TOTAL STUDENTS --- 188  STUDENT RIDING TIME ---    4619  ROUTE TIME ---  104
```

3 1 10 2 15 10 8 5 6 ~~7~~ 0
31 7 6 5 36 4 3 2 1 8 40
732 733 736 737 738 740 741 742 743 746 800
BUS NO. 1 NUMBER OF STUDENTS ~~66~~ 67 ROUTE TIME 28 STUDENT RIDING TIME 1355 GENERATION NO. 1

~~1~~ 18 1 4 4 5 2 1 6 1 1 5 1 9 ~~7~~ 0
~~8~~ 9 10 11 37 22 21 20 19 18 24 29 30 35 ~~34~~ 40
~~719~~ 720 721 723 724 725 726 727 728 729 730 737 739 741 ~~743~~ 800
BUS NO. ~~1~~ 2 NUMBER OF STUDENTS ~~66~~ 58 ROUTE TIME 41 STUDENT RIDING TIME 2047 GENERATION NO. 2

~~15~~ 3 2 5 1 2 3 1 3 2 10 4 1 1 7 3 0
34 38 25 26 27 33 28 23 32 12 13 14 15 39 16 17 40
725 726 727 728 729 732 733 739 742 743 744 745 747 748 751 752 800
BUS NO. 3 NUMBER OF STUDENTS ~~58~~ 63 ROUTE TIME 35 STUDENT RIDING TIME 1217 GENERATION NO. 3

```
   03ELEM  JR    SR
   01   67
   02   58
   03   63
9999
   01   006
   02   005
   03   008
   04   010
   05   002
   06   010
   07   001
   08   007
   09   018
   10   001
   11   004
   12   002
   13   010
   14   004
   15   001
   16   007
   17   003
   18   001
   19   006
   20   001
   21   002
   22   005
   23   001
   24   001
   25   002
   26   005
   27   001
   28   003
   29   005
   30   001
   31   003
   32   003
   33   002
   34   015
   35   009
   36   015
   37   004
   38   003
   39   001
   40
9999
   01   02   01   08   03   40   11   10   05
   02   01   01   03   01   40   10
   03   02   01   04   01   40   09
   04   03   01   05   01   40   08   36   02
   05   04   01   06   01   36   01   11   02   40   07
   06   05   01   07   03   40   06   36   02
   07   06   03   31   01   13   03   40   03
   07   36   05
   08   01   03   09   01   18   02   40   14   24   03   10   02
```

Input for Generated Routes
(Continued)

```
09  08  01  10  01  40  12
10  09  01  11  02  40  11  01  05  18  04
11  10  02  12  04  37  01  05  02  40  09
11  31  05
12  11  04  13  01  31  01  32  01  40  05
13  12  01  14  01  40  06  23  05  07  03
13  31  02
14  13  01  15  02  40  07  39  03  17  04
15  14  02  39  01  16  02  40  05
16  15  02  17  01  40  07  39  03
17  16  01  15  03  40  08
18  08  02  19  01  24  01  40  16  10  04
19  18  01  20  01  40  17
20  19  01  21  01  40  13
21  20  01  22  01  40  12  37  02
22  21  01  37  01  23  02  25  04  40  11
23  37  03
23  22  02  32  03  28  06  40  09
24  18  01  25  07  29  07  40  16  08  03
24  10  05
25  24  07  26  01  38  01  22  04  29  08  40  15
26  25  01  27  01  40  14
27  26  01  28  02  40  13  33  03
28  27  02  33  01  32  05  23  06  15  10  17  15  40  11
29  24  07  25  08  40  23  30  02
30  29  02  35  02  40  21
31  07  01  12  01  40  04
31  13  02
31  37  03
31  36  06  11  05
32  12  01  23  03  28  05  33  16  40  06
33  28  01  40  12  27  03
34  38  01  35  02  40  17
35  34  02  30  02  40  19
36  05  01  40  08  04  02  06  02
37  11  01  22  01  40  10  23  03  21  02
38  25  01  34  01  40  16
39  15  01  40  04  14  03  16  03  17  04
9999
40  01  200
31
07
06
05
36
04
03
02
01
08
40
9999
40  02  200
09
10
```

Input for Generated Routes
(Continued)

```
   11
   37
   22
   21
   20
   19
   18
   24
   29
   30
   35
   40
 9999
   40   03   200
   34
   38
   25
   26
   27
   33
   28
   23
   32
   12
   13
   14
   15
   39
   16
   17
   40
 9999
/*
```

Output from Generated Routes
Bus No. 1

```
   3    1   10    2   15   10    8    5    6    7    0
  31    7    6    5   36    4    3    2    1    8   40
 732  733  736  737  738  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   28  STUDENT RIDING TIME     1369  GENERATION NO.    1

   3    1   10   15    2   10    8    5    6    7    0
  31    7    6   36    5    4    3    2    1    8   40
 732  733  736  738  739  740  741  742  743  746  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   28  STUDENT RIDING TIME     1365  GENERATION NO.    2

   7    6    5    8   10    2   10    1    3   15    0
   8    1    2    3    4    5    6    7   31   36   40
 734  737  738  739  740  741  742  745  746  752  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   26  STUDENT RIDING TIME     1193  GENERATION NO.    7

   7    6    5    8   10    2   15   10    1    3    0
   8    1    2    3    4    5   36    6    7   31   40
 742  745  746  747  748  749  750  752  755  756  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   18  STUDENT RIDING TIME      779  GENERATION NO.    8

   7    6    5    8   10   15    2   10    1    3    0
   8    1    2    3    4   36    5    6    7   31   40
 742  745  746  747  748  750  751  752  755  756  800
BUS NO.   1  NUMBER OF STUDENTS   67  ROUTE TIME   18  STUDENT RIDING TIME      775  GENERATION NO.    9
```

Output from Generated Routes
Bus No. 2

```
 18    1    4    4    5    2    1    6    1    1    5    1    9    0
  9   10   11   37   22   21   20   19   18   24   29   30   35   40
720  721  723  724  725  726  727  728  729  730  737  739  741  800
BUS NO.   2  NUMBER OF STUDENTS   58  ROUTE TIME   40  STUDENT RIDING TIME      1887  GENERATION NO.     1

  9    1    5    1    1    6    1    2    5    4    4    1   18    0
 35   30   29   24   18   19   20   21   22   37   11   10    9   40
727  729  731  738  739  740  741  742  743  744  745  747  748  800
BUS NO.   2  NUMBER OF STUDENTS   58  ROUTE TIME   33  STUDENT RIDING TIME      1129  GENERATION NO.     2
```

Output from Generated Routes
Bus No. 3

```
   15    3    2    5    1    2    3    1    3    2   10    4    1    1    7    3    0
   34   38   25   26   27   33   28   23   32   12   13   14   15   39   16   17   40
  725  726  727  728  729  732  733  739  742  743  744  745  747  748  751  752  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   35  STUDENT RIDING TIME     1462  GENERATION NO.    1

   15    3    2    5    1    2    3    1    3    2   10    4    1    1    3    7    0
   34   38   25   26   27   33   28   23   32   12   13   14   15   39   17   16   40
  725  726  727  728  729  732  733  739  742  743  744  745  747  748  752  753  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   35  STUDENT RIDING TIME     1448  GENERATION NO.    2

   15    3    2    5    1    2    3    1    3    2   10    4    1    1    7    3    0
   34   38   25   26   27   33   28   23   32   12   13   14   39   15   16   17   40
  725  726  727  728  729  732  733  739  742  743  744  745  748  749  751  752  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   35  STUDENT RIDING TIME     1460  GENERATION NO.    4

   15    3    2    5    1    2    3    1    3    2   10    4    1    7    3    1    0
   34   38   25   26   27   33   28   23   32   12   13   14   39   16   17   15   40
  725  726  727  728  729  732  733  739  742  743  744  745  748  751  752  755  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   35  STUDENT RIDING TIME     1454  GENERATION NO.    5

   15    3    2    5    1    2    3    1    3    2   10    4    1    3    7    1    0
   34   38   25   26   27   33   28   23   32   12   13   14   39   17   16   15   40
  725  726  727  728  729  732  733  739  742  743  744  745  748  752  753  755  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   35  STUDENT RIDING TIME     1440  GENERATION NO.    7

   15    3    2    5    1    2    3    1    3    2   10    4    3    7    1    1    0
   34   38   25   26   27   33   28   23   32   12   13   14   17   16   15   39   40
  728  729  730  731  732  735  736  742  745  746  747  748  752  753  755  756  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   32  STUDENT RIDING TIME     1279  GENERATION NO.   10

   15    3    2    5    1    2    3    1    3    2   10    4    3    7    1    1    0
   34   38   25   26   27   33   28   23   32   12   13   14   17   16   39   15   40
  726  727  728  729  730  733  734  740  743  744  745  746  750  751  754  755  800
BUS NO.   3  NUMBER OF STUDENTS   63  ROUTE TIME   34  STUDENT RIDING TIME     1403  GENERATION NO.   11
```

INPUT FOR PRINTING SELECTED GENERATIONS

```
   01
   01   66
   02   66
   03   66
 9999
```

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

```
9999
    1    13418 7 1/2 MILE RD
    2    13324 7 1/2 MILE RD
    3    13032 7 1/2 MILE RD
    4    12502 7 1/2 MILE RD
    5    12400 7 1/2 MILE RD
    6    12006 7 1/2 MILE RD
   07    HWY 38 & 7 1/2 MILE RD
    8    8049 HWY 41
   09    7 MILE RD & HAGEMANN RD
   10    12813 7 MILE RD
   11    12329 7 MILE RD
   12    8123 HY 38
   13    10207 7 MILE RD
   14    9807 7 MILE RD
   15    9326 7 MI RD & NICHOLSON RD
   16    8510 7 MILE RD
   17    7920 7 MILE RD
   18    13410 6 1/2 MILE RD
   19    13116 6 1/2 MILE RD
   20    12926 6 1/2 MILE RD
   21    12500 6 1/2 MILE RD
   22    7600 HWY V
   23    11026 6 1/2 MILE RD
   24    7153 HWY 41
   25    6601 HWY V
   26    11933 HY G
   27    11001 HWY G
   28    10612 HWY G
   29    13500 BELL RD
   30    13131 BELL RD
   31    8348 HY 38
   32    HWY 38 AND FOREST HILL RD
   33    6237 HY H
   34    5955 HWY V
   35    5544 HWY V
   36    8645 EAU GALLE RD
   37    7826 HWY V
   38    6205 HWY V
   39    8405 NICHOLSON RD
   40    CADDY VISTA SCHOOL
9999
  01 0800 0300 0750 0305    09
  02 0800 0300 0750 0305    02
  03 0800 0300 0750 0305    10
9999
```

BUS ROUTE 1 -- GENERATION 9

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

BUS NUMBER -----		DRIVER ----------			
ROUTE NUMBER	1	GENERATION	9	ROUTE TIME	18
NO. TRANSPORTED	67	BUS CAP.	66	STUDENT TIME	775
SCHOOL STARTING TIME	8.00 A.M.	SCHOOL DISMISSAL TIME		3.00 P.M.	
SCHOOL ARRIVAL TIME	7.50 A.M.	SCHOOL LEAVING TIME		3.05 P.M.	

POINT	ADDRESS	A.M. ARRIVAL TIME	P.M.	NO. OF STUDENTS ELEM	JR	SR
8	8049 HWY 41	7.32	3.23	7		
1	13418 7 1/2 MILE RD	7.35	3.20	6		
2	13324 7 1/2 MILE RD	7.36	3.19	5		
3	13032 7 1/2 MILE RD	7.37	3.18	8		
4	12502 7 1/2 MILE RD	7.38	3.17	10		
36	8645 EAU GALLE RD	7.40	3.15	15		
5	12400 7 1/2 MILE RD	7.41	3.14	2		
6	12006 7 1/2 MILE RD	7.42	3.13	10		
7	HWY 38 & 7 1/2 MILE RD	7.45	3.10	1		
31	8348 HY 38	7.46	3.09	3		
40	CADDY VISTA SCHOOL	7.50	3.05			

BUS ROUTE 2 -- GENERATION 2

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

BUS NUMBER -----		DRIVER ----------	
ROUTE NUMBER 2	GENERATION 2	ROUTE TIME	33
NO. TRANSPORTED 58	BUS CAP. 66	STUDENT TIME	1129
SCHOOL STARTING TIME 8.00 A.M.		SCHOOL DISMISSAL TIME	3.00 P.M.
SCHOOL ARRIVAL TIME 7.50 A.M.		SCHOOL LEAVING TIME	3.05 P.M.

POINT	ADDRESS	A.M. ARRIVAL TIME	P.M.	NO. OF STUDENTS ELEM	JR	SR
35	5544 HWY V	7.17	3.38	9		
30	13131 BELL RD	7.19	3.36	1		
29	13500 BELL RD	7.21	3.34	5		
24	7153 HWY 41	7.28	3.27	1		
18	13410 6 1/2 MILE RD	7.29	3.26	1		
19	13116 6 1/2 MILE RD	7.30	3.25	6		
20	12926 6 1/2 MILE RD	7.31	3.24	1		
21	12500 6 1/2 MILE RD	7.32	3.23	2		
22	7600 HWY V	7.33	3.22	5		
37	7826 HWY V	7.34	3.21	4		
11	12329 7 MILE RD	7.35	3.20	4		
10	12813 7 MILE RD	7.37	3.18	1		
9	7 MILE RD & HAGEMANN RD	7.38	3.17	18		
40	CADDY VISTA SCHOOL	7.50	3.05			

BUS ROUTE 3 -- GENERATION 10

SCHOOL BUS ROUTING FOR
THE BOARD OF PUBLIC INSTRUCTION OF RACINE, WISCONSIN
BY THE UNIVERSITY OF MISSISSIPPI

CADDY VISTA SCHOOL (8.00 SESSION)
RACINE , WISCONSIN

BUS NUMBER -----		DRIVER ----------	
ROUTE NUMBER 3	GENERATION 10	ROUTE TIME	32
NO. TRANSPORTED 63	BUS CAP. 66	STUDENT TIME	1279
SCHOOL STARTING TIME 8.00 A.M.		SCHOOL DISMISSAL TIME	3.00 P.M.
SCHOOL ARRIVAL TIME 7.50 A.M.		SCHOOL LEAVING TIME	3.05 P.M.

POINT	ADDRESS	A.M. ARRIVAL TIME	P.M.	NO. OF STUDENTS ELEM	JR	SR
34	5955 HWY V	7.18	3.37	15		
38	6205 HWY V	7.19	3.36	3		
25	6601 HWY V	7.20	3.35	2		
26	11933 HY G	7.21	3.34	5		
27	11001 HWY G	7.22	3.33	1		
33	6237 HY H	7.25	3.30	2		
28	10612 HWY G	7.26	3.29	3		
23	11026 6 1/2 MILE RD	7.32	3.23	1		
32	HWY 38 AND FOREST HILL R	7.35	3.20	3		
12	8123 HY 38	7.36	3.19	2		
13	10207 7 MILE RD	7.37	3.18	10		
14	9807 7 MILE RD	7.38	3.17	4		
17	7920 7 MILE RD	7.42	3.13	3		
16	8510 7 MILE RD	7.43	3.12	7		
15	9326 7 MI RD & NICHOLSON	7.45	3.10	1		
39	8405 NICHOLSON RD	7.46	3.09	1		
40	CADDY VISTA SCHOOL	7.50	3.05			

SECTION G

DATA SET REQUIREMENTS FOR SCHOOL BUS ROUTING PROGRAM

The School Bus Routing Program uses two sequential data sets, which are composed of 80 byte records. The data sets are referenced with data set reference numbers 1 and 2.

The number of records in the data set with DSRN 1 is

Number of Records = 2 + [(NBC+MPTN+NREL+MTYPE) *2] /80

where NBC, MPTN, NREL, and MTYPE are the number of entries in the arrays with corresponding names in the program. If the variables were dimensioned in the following statement, the number of records required would be 29.

```
DIMENSION  NBC(50), MPTN(150), MREL(150), MTYPE(150,5)
```

The number of records in the data set with DSRN 2 is variable. For each bus route printed, five records are required. Therefore, the number of records needed is

Number of Records = 5 * N

where N is the number of busses for suggested routes and sum of the number of generation printed for each bus route for generated routes. For example, 1000 records would allow for 200 generated routes.

When suggested routes are being prepared, the data sets can be dummied, since the data from suggested routes is never used.

If it is not necessary to keep the data stored on data sets 1 and 2, cards 174, 175, 645, 647 can be removed from the deck and the data sets will not be used.